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APPLICATIONS MANUAL

MODEL T195
LEVEL TRACER

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wilcom
WILCOM PRODUCTS INC.
P.O. BOX 508
LACONIA, N.H. 03246
PHONE: 603-524-2622
TWX: 510-298-1120

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MODEL T195 LEVEL TRACER APPLICATIONS MANUAL

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ALL WILCOM products are warranted against defects in materials and workmanship. This warranty applies for a period of one year from date of delivery, except in specialized cases where a different period may be specified for particular items.

WILCOM'S obligation under this warranty is limited to servicing or adjusting each instrument returned to its factory within the warranty period, and to replace any components which are found to be defective. If in WILCOM'S judgment the defective condition is a result of misuse or abnormal operation, repairs will be billed.

If faulty conditions develop, notify WILCOM for instructions. Servicing information will be supplied wherever possible. If the equipment is to be returned for repairs, please include a description of the faulty condition and who should be contacted if additional information is needed. Ship the equipment prepaid.

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MODEL T195
LEVEL TRACER

CONTENTS

SECTION	DESCRIPTION		PAGE
1.0	**General**		
	1.1	Description	1-4
	1.2	Features and Capabilities	1-1
	1.3	Accessory Equipment	1-4
	1.4	Related Equipment	1-4
	1.5	Factory Options	1-5
2.0	**Specifications**		
	2.1	Send Section	2-1
	2.2	Receive Section	2-1
	2.3	Display	2-2
	2.4	General Specifications	2-2
3.0	**Panel Controls and Connections**		
	3.1	General	3-1
	3.2	Input/Output Connections	3-1
	3.3	Input Controls	3-1
	3.4	Output and Amplifier Controls	3-3
	3.5	Sweep Controls	3-3
	3.6	TRACE 1 Controls	3-3
	3.7	TRACE 2 Controls	3-4
	3.8	Display and Vertical Scale Controls	3-4
	3.9	Miscellaneous Controls	3-4
4.0	**Operating Instructions**		
	4.1	General	4-1
	4.2	Initial Conditions	4-1
	4.3	Dial and Hold	4-1
	4.4	Sending Tones	4-1
	4.5	CRT Trace Display	4-2
	4.6	Line Selections and Updating the Display Traces	4-2
	4.7	Test Selection	4-2
	4.8	Level Measurements (LEVEL)	4-2
	4.9	Impedance Measurements (IMP)	4-3
	4.10	Return Loss Measurements (RTN LOSS)	4-6
	4.11	AVERAGE OVER BAND Function	4-6
	4.12	LOW FREQ REJ Function	4-6
5.0	**Applications**		
	5.1	General	5-1
	5.2	Impedance Measurements	5-1
	5.3	Impedance Measurements with Precision Network Termination	5-1
	5.4	Impedance Measurement with Impedance Compensator	5-1

5.5	Capacitance Measurements	5-2
5.6	Resistance Measurements	5-2
5.7	Determining Length of Cable	5-3
5.8	Determining Distance to an Open Circuit Fault	5-4
5.9	Determining Distance to a Short Circuit Fault	5-4
5.10	Level Measurements Using Internal Generator	5-5
5.11	Level Measurements Using an External Signal Generator	5-5
5.12	Level Measurements Using External Fixed Frequency Generator	5-5
5.13	Loop Around Level Measurements	5-6
5.14	Return Loss Measurements with Precision Networks	5-6
5.15	Return Loss Measurements with Compromise Network and Impedance Compensator	5-6
5.16	Comparing Against an Artificial Line	5-7
5.17	Locating Bridged Taps	5-7
5.18	Comparing Tip and Ring Characteristics with Respect to Ground	5-8
5.19	Checking for Split Pairs	5-8
5.20	Test for Bridged Ringers	5-8
5.21	Test for Grounded Ringers	5-9
5.22	Noise Measurements	5-9
5.23	Recording Patterns by Camera or Tracings	5-9
5.24	Recording with an X-Y Plotter	5-9

1.0 GENERAL

1.1 Description

1.1.01 This manual describes the Wilcom Model T195 Level Tracer. The Level Tracer is a full send/receive instrument capable of measuring multiple telephone line parameters and displaying the parameters as continuous functions of frequency over all, or a selected portion, of the 20 to 20,000 Hz frequency band.

1.1.02 Two independent traces of measured transmission level, return loss, or impedance parameters can be presented simultaneously on the T195's CRT display screen. Either or both of the traces can display present measurement results, or past measurements results, read from storage in the T195's digital memory.

1.1.03 Thus, the T195 is capable of measuring and displaying:

(1) the characteristics of two individual telephone lines;

(2) the characteristics of a single telephone line before and after changes such as loading, build-out, conditioning, gain correction, or any other adjustment . . . the effects of such changes can be observed in seconds;

(3) the characteristics of a single telephone line versus the characteristics of a comparison standard;

(4) the characteristics of a single line's T and R leads to ground.

1.1.04 Because of these capabilities and other new concepts in level tracer design, the T195 makes testing faster and easier in maintenance, engineering, and cable acceptance work. It makes available various new measurement and analytical techniques not possible with instruments of previous design. Its special features and capabilities are briefly described in the following paragraphs.

1.2 Features and Capabilities

1.2.01 Each measurement made by the T195 is digitized and stored in solid state memory from which the displayed traces are derived. Either or both of the traces can be updated with new measurement data continuously or periodically as desired. Data from a measurement can be retained indefinitely in the memory for either trace, permitting a user to hold past measurement traces on the screen as long as needed. The traces are displayed with constant brightness regardless of how long they are held on the screen.

1.2.02 The CRT screen has a calibrated graticule (like an oscilloscope) from which level, return loss, and impedance values can be read directly over the frequency range covered by a measurement. Positioning controls allow the traces to be superimposed or separated as needed to match and compare their variations.

1.2.03 For some tests, the instrument can be manually tuned to acquire measurement data at specific frequencies. Or, it can be set to automatically sweep across any of four frequency ranges . . . from 20 Hz on the low end to 400, 4000, 8000, or 20,000 Hz on the high end.

1.2.04 For transmission level measurements, the T195 can also be set to automatically seek, lock on, and then track the frequency of a test signal incoming from an external source. Lock on and tracking are fully automatic regardless of whether the external source is a swept frequency generator, a manually-tuned test set/oscillator, or a fixed frequency unit such as a regular office milliwatt test line.

1.2.05 In all cases, test frequency is displayed on a front panel digital readout with an accuracy of ±1 Hz. Smaller marker "pips" can also be switched on to indicate test frequency on the displayed CRT traces.

1.2.06 In level test mode, the T195's measure/display section can handle an extremely wide input level range . . . from +20 to −89 dBm. Using a swept frequency test signal and appropriate control settings, the CRT trace will show the frequency response curve of a circuit under test with such fidelity that level variations as small as±0.2 dB can be clearly seen.

1.2.07 The level measurement input configuration is pushbutton selectable for terminating or bridging connections on circuits of 150, 600, and 900 ohms impedance. Internal calibration is automatically controlled such that the CRT reads correctly in dBm for the circuit impedance selected.

1.2.08 The T195's precision internal oscillator can be used in level measurements as a send section (source) of manually-tuned or swept frequency signal for transmission into a circuit under test. Send impedances of 150, 600, and 900 ohms are selectable.

1.2.09 The oscillator's output signal is automatically leveled to maintain amplitude constant within±0.2 dB over the entire tuning range. Thumbwheel switches allow the output to be set anywhere between +19 and −49 dBm in 1-dB steps. As required, a user may instruct the T195 to cut off the transmitted signal automatically any time tuning enters a 300 Hz band centered at 2600 Hz.

1.2.10 Both send and receive portions of the T195 are equipped with dial and hold provisions to permit convenient, one-man level measurements through a loop-around test line. In such uses the T195 sends into one leg of the loop while simultaneously measuring and displaying the signal received from the loop's other leg.

1.2.11 In return loss mode, the T195 makes manually-tuned or swept frequency measurements over a 0 to 45 dB return loss range. The following provisions are built-into the T195 for return loss measurements:

(1) precision hybrid;

(2) thumbwheel-selectable build-out capacitance covering 0.001 to 0.999 uF in 0.001 uF steps with accuracy of±1 percent;

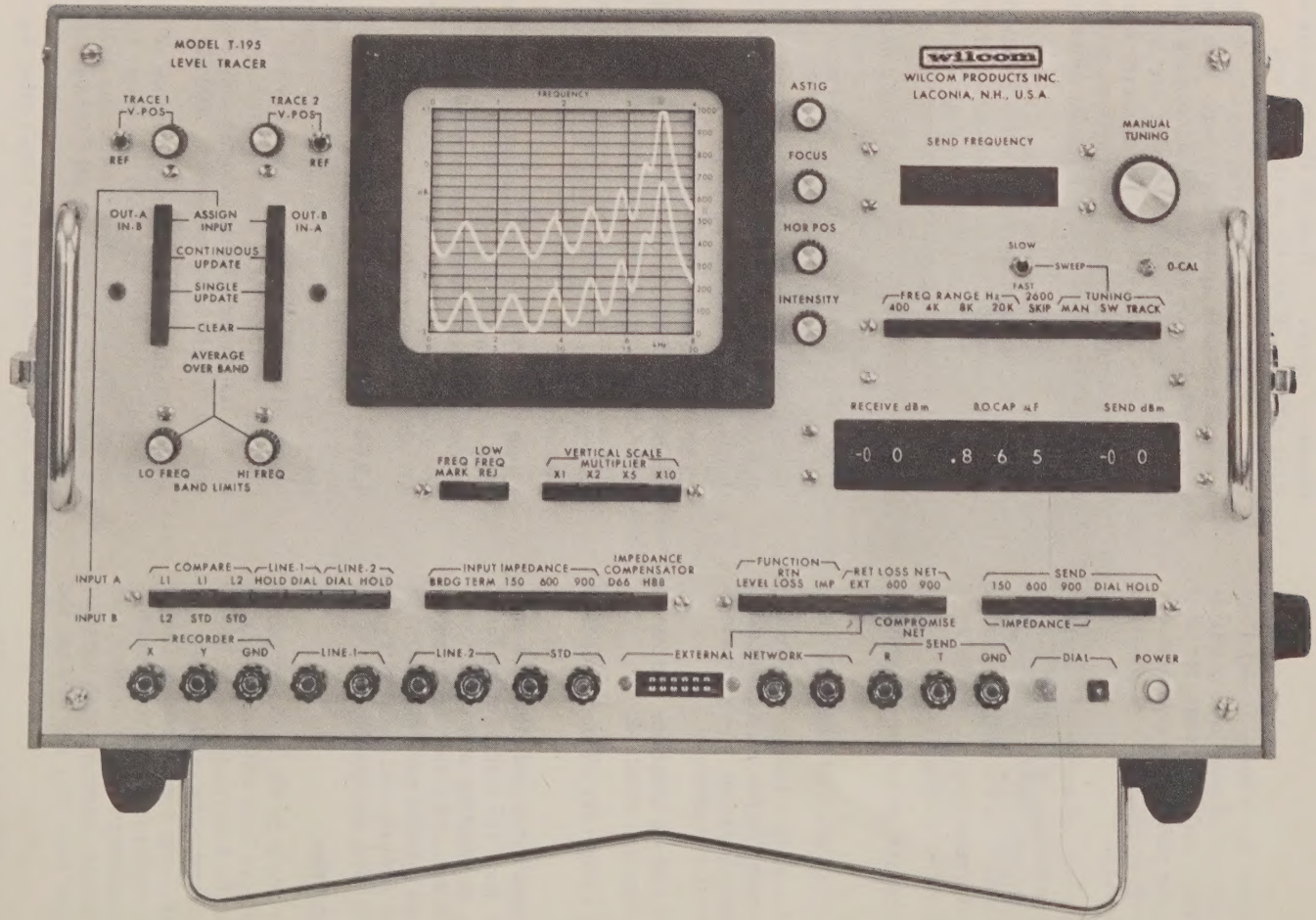
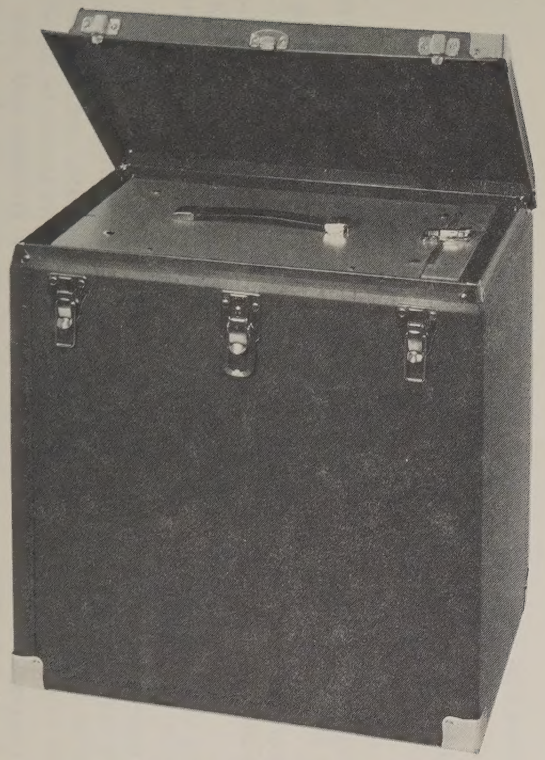
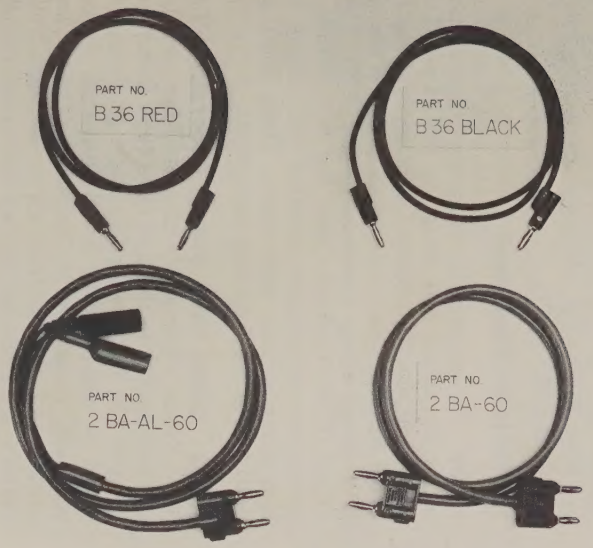


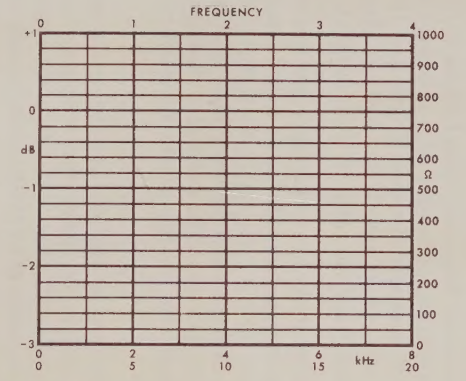
FIGURE 1-1
Model T195 Level Tracer



Carrying Case

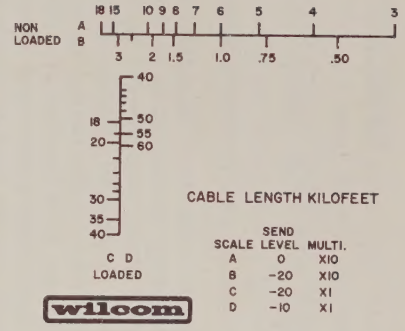


Patch Cords



T195GO

Graticules



Loop Length

FIGURE 1-2
Accessory Equipment

(3) switch-selectable impedance compensators for H88 and D66 loaded cable;

(4) switch selectable compromise network of 600 or 900 ohms in series with 2.16 uF;

(5) panel connections for an external precision network.

1.2.12 In impedance mode, the T195 makes manually-tuned or swept frequency measurements of impedances between 0 and 10,000 ohms. Accuracy and resolution of the swept frequency impedance display is such that characteristic variations of cables having up to 20 load points can be clearly seen. Even the effect of a missing 19th load coil becomes immediately visible when a trace of that cable is superimposed over the trace of a normal 20 load point cable.

1.2.13 The impedance mode may also be used to find the capacitance or resistance of loaded or non-loaded cable. This permits determination of cable length and the distance to shorts or opens. (With an artificial line, the locations of bridged taps can also be determined.)

1.2.14 An internal measurement integration feature can be switch-selected in either impedance or return loss mode. This feature causes the CRT display to show impedance or return loss as an average value between high and low frequency limits set by the user. The average is displayed as a straight, horizontal line on the screen between the two frequency limits.

1.2.15 Both echo return loss and singing return loss can be conveniently measured using the averaging feature. And, this feature greatly facilitates building-out a precision network with capacitance until the best return loss value is obtained. The effects of build-out capacitance changes as small as 0.001 uF can be easily observed.

1.3 Accessory Equipment

1.3.01 Four patch cords are available for connections to circuits under test. They are described in Table 1-1.

TYPE	DESCRIPTION
2BA-60	5 feet long, twin banana plug at each end
2BA-AL-60	5 feet long, twin banana plug at one end and two aligator clips at the other end
B36 RED	3 feet long, single conductor with a banana plug at each end
B36 BLACK	3 feet long, single conductor with a banana plug at each end

1.3.02 The T195G0 graticule overlay is available which may be mounted on the front of the T195 Level Tracer. The overlay permits the recording of the impedance, return loss on level characteristics with a felt tip pen. These data may be reproduced on a copy machine for a permanent record and the graticules wiped clean for re-use.

1.3.03 A loop Length Measuring Graticule is also available and may be mounted on the front of the T195 Level Tracer. This graticule allows direct measurement of loop length of loaded or non-loaded cable facilities.

1.3.04 A fiber board carrying case, Model T195CC, is available to provide additional protection for the T195 during transportation.

1.4 Related Equipment

1.4.01 Two companion equipment items are particularly useful in various tests using the T195 Level Tracer. The Wilcom Model T205 Sweep Generator is an ideal source of swept frequency level test signals for use at the distant end of a circuit being examined by the T195. The Wilcom Model T240 Artificial Cable Kit is a flexible, accurate comparison/simulation standard particularly helpful in diagnosing various cable faults. These items are briefly described in the following paragraphs.

1.4.02 Model T205 Sweep Generator - The Model T205 Sweep Generator's characteristics and capabilities are very similar to those of the T195's internal sweep oscillator. The T205 Sweep Generator produces a manually-tuned or automatically swept frequency output in four selectable ranges up to 20,000 Hz. Output level is adjustable in 1 dB steps from +9 to −49 dBm. Two separate outputs are provided so two individual circuits can be tested simultaneously without interference between the two.

1.4.03 Model T240 Artificial Cable Kit - The Model T240 Artificial Cable Kit contains line-section modules which closely represent actual telephone cable sections. The kit has facilities which can be used in conjunction with the T195 Level Tracer to simplify and expedite analysis of numerous cable fault conditions.

1.4.04 With the kit, simulated cable fault conditions can be introduced and removed via switches, without need to physically disconnect modules from the artificial line and then reassemble the line. The kit makes it easy to set up for analyzing the effects of:

(1) split pairs,

(2) bridged taps,

(3) unbalanced grounded ringers,

(4) high series resistance unbalance,

(5) shunt capacitance unbalance,

(6) missing or improperly connected load coils,

(7) multiple ringers bridged on a loop,

(8) and other cable conditions.

The kit has appropriate precision and compromise networks for return loss and impedance measurements.

1.4.05 Recording Patterns by Camera

(1) A polaroid camera with a close-up lens and mounted on a tripod or a solid table surface will provide usable photographs. The camera should be placed so the lens is about 10" from the graticule and then focused. The brightness of the trace can be adjusted with the

INTENSITY control. Incident light does not hurt the picture; however, bright sunlight should be avoided and a shade should be used.

(2) The Tektronix C-5A Camera may be held against the Level Tracer bezel during exposure to provide photographs without external support or ambient light. Shadows of some graticule lines, caused by the camera flash, will be visible on the CRT.

1.5 Factory Options

1.5.01 Variable Sweep Speed - The Level Tracer may be ordered with a continuously variable knob control to replace the SLOW/FAST toggle switch. The control allows sweep speed to be adjusted from approximately 1.5 seconds to 25 seconds.

2.0 SPECIFICATIONS

2.1 Send Section

2.1.01 Frequency:

Range: 20 Hz to 20 kHz in four bands as follows:

20 to 400 Hz
20 to 4000 Hz
20 to 8000 Hz
20 to 20,000 Hz

Tuning:

SWP: Automatic linear frequency sweep through selected range.

Sweep Rate: Slow (approximately 5 seconds for full sweep) or Fast (approximately 1-1/2 seconds).

MAN: Manual tuning through selected range.

TRACK: Locks to and follows received frequency.

DISPLAY: Digital readout to nearest 1 Hz.

Marker: Switch selectable. A short vertical line on each display trace indicating the present Send Frequency.

SF SKIP: Switch selectable. Send output is switched off when generator frequency is in a 300 Hz band centered at 2600 Hz.

2.1.02 Level:

Range: +19 to −49 dBm

Control: Thumbwheel switches, one dB steps

Accuracy at 1 kHz: ±0.2 dB, at any control setting and all operating conditions within ratings.

Accuracy vs frequency: +0.2 dB, 100 Hz to 20 kHz for 600 ohms or 900 ohms SEND IMPEDANCE; 500 Hz to 20 kHz for 150 ohms. (At lower frequencies, terminated Send Level accuracy is limited by loss in dc blocking capacitors.)

2.1.03 Output Impedance: Selectable 150, 600 or 900 ohms ±1%, balanced and dc blocked for 300 volts.

2.1.04 Distortion: Total harmonic distortion more than 60 dB below fundamental frequency level (f• 100 Hz)

2.1.05 Noise: −70 dBm (0-20 kHz BW)

2.2 Receive Section

2.2.01 Functions: Level, Return Loss, Impedance.

2.2.02 Ranges:

LEVEL:

At 0 dB on graticule: −59 dBm to +19 dBm.

Including readable graticule range with X10 multiplier: −89 dBm to +20 dBm

RET LOSS: 0 to 45 dB

IMP: 0 to 10,000 ohms.

2.2.03 Level and Return Loss Attenuator:

Thumbwheel switches designated RECEIVE dBm, set zero level on graticule in 1 dB steps.

2.2.04 Accuracy (at 1 kHz):

LEVEL & RETURN LOSS:

At zero reference on graticule: ±0.2 dB for any attenuator switch setting and all operating conditions within ratings.

Scale deflection: ±3% of reading

IMPEDANCE:

100 ohms to 1 k ohms:

±(1% of scale +3% of reading.)

Below 100 ohms:

Above 1 k ohms: Additional error caused by 100 k ohms shunt across impedance being measured.

2.2.05 Frequency Response (referred to 1 kHz):

LEVEL:

BRDG: ±0.2 dB, 20 Hz to 20 kHz

TERM:

600 or 900 ohms: ±0.2 dB, 200 Hz to 20 kHz

150 ohms: ±0.2 dB, 500 Hz to 20 kHz

RET LOSS: ±0.2 dB, 20 Hz to 20 kHz

IMP: ±2%, 20 Hz to 20 kHz

2.2.06 Input Impedance:

LEVEL: Switch selectable 150, 600, or 900 ohms TERM or approximately 100,000 ohms BRDG, balanced and dc blocked for 300 volts.

RET LOSS: Equals network impedance.

IMP: Approximately 100,000 ohms.

2.2.07 Longitudinal Balance: Greater than 80 dB up to 4 kHz.

2.2.08 Input Noise (no signal):

Less than −85 dBm when terminated.

2.2.09 Tracking: In LEVEL function, the send generator will track a receive frequency with receive level between 10 dB above and 30 dB below the zero reference on graticule. (−89 dBm to +20 dBm limits.)

2.2.10 AVERAGE OVER BAND: Switch selectable. When this function is selected, the stored data for trace 2, over a selected frequency band, is averaged as it is dis-

played and appears as a horizontal line at the average value between the selected frequency limits.

IMPED: Linear average of impedance over selected band.

LEVEL or RET LOSS: Quasi power average, or a non-linear average of the stored dB level over the selected band, designed to approximate a true power average expressed in dB.

2.2.11 Miscellaneous Receive Features:

LOW FREQ REJ: Switch selectable,

60 Hz: down down greater than 60 dB
180 Hz: down approximately 15 dB
300 Hz: down less than 3 dB

RET LOSS NET: Switch selectable:

EXT: Socket for Wilcom precision net, in parallel with binding posts.

600 COMPROMISE NET: 600 ohms ±1% in series with 2.15 uF.

900 COMPROMISE NET: 900 ohms ±1% in series with 2.16 uF.

IMPEDANCE COMPENSATOR: Switch selectable. Inductor inserted in series with line for impedance compensation:

H88: 44 mH

D66: 33 mH

B.O. CAP: Build out decade capacitor settable by 3-decade thumbwheel switches, to .999 uF in .001 uF increments. Overall tolerance ±1%. The B.O. Cap is connected across the line if either H88 or D66 compensation is selected. It is connected across the EXT NET terminals if neither impedance compensation is selected.

2.3 Display

2.3.01 Trace: Dual trace with separate storage for each trace, and continuous presentation of stored data.

2.3.02 Viewing area: 80 x 95 mm.

2.3.03 Graticule: Vertical - linear dB and ohms; horizontal - frequency.

2.3.04 Vertical Scales:

Multiplier: 1X, 2X, 5X, 10X.

dB Scale: 0.2, 0.4, 1 and 2 dB divisions depending on vertical scale multiplier.

Impedance Scale: 50, 100, 250, and 500 ohm divisions depending on vertical scale multiplier.

2.3.05 Horizontal Frequency Scale: 50, 500, 1000 and 2500 Hertz divisions depending on frequency range setting.

2.3.06 Data Updating: Selectable, continuous update on each frequency sweep or single update on one frequency sweep; two channels may be continually updated on alternate frequency sweeps; one channel may retain old data and second channel may be updated to display new data.

2.3.07 Trace Positioning: Both traces may be referred to the scale calibration; or, vertical positioning controls can separate the traces.

2.4 General Specifications

2.4.01 Recorder Output:

X Terminal: Output voltage proportional to send frequency.

Y Terminal: Output voltage proportional to receive level being stored.

Full Scale X or Y Output Level: 5 volts into a high impedance or 1 mA into 100 ohms.

Output Impedance: 4.9 k ohms (approximately).

2.4.02 Dial and Hold: Terminals are provided to attach a lineman's telephone set to dial a test number on a line under test. A switchable electronic hold circuit is provided to hold the line during measurements.

2.4.03 Environmental Conditions:

Operating Temperature: 0 to 50°C (to −25°C with reduced accuracy.)

Humidity: 95% at 35°C; 40% at 50°C

Storage Temperature: −55°C to +70°C

Altitude: (non-operating) 50,000 feet

2.4.04 Power: 115V/230V ±10%, 50-60 Hz, 43 watts

2.4.05 Size: 10 3/8"H x 17 5/8"W x 17 3/4"D; 26.4 cm H x 44.8 cm W x 45 cm D.

2.4.06 Weight: 38 lbs. (16.3 kg)

3.0 PANEL CONTROLS AND CONNECTIONS

3.1 General

3.1.01 This section describes the function of each switch, control, lamp and connector external to the Model T195 Level Tracer.

3.1.02 This section is sub-divided into sections relating to input/output connections, input controls, output and amplifier controls, sweep controls, trace controls, display and vertical scale controls, and miscellaneous controls.

3.1.03 Figure 3-1 will locate the connections and controls by the subdivisions of this section.

3.1.04 Pushbutton action definitions–

(1) Push-push: The switch remains engaged when pressed and must be pressed again to release. The switch function continues as long as the switch remains engaged.

(2) Interlocking: Consists of a group of two or more switches. When any switch in a group is pressed, it automatically releases any other switch that was engaged. The switch function continues until released by pressing another switch in that group.

(3) Interlocking with lockout: Has the same effects as the interlocking action except that no two interlocking buttons may be pressed at one time.

(4) Momentary: The switch remains in only as long as it is pressed. The switch returns to its original position as soon as pressure is removed.

(5) Engaged: The "in" or low profile position.

(6) Released: The "out" or high profile position.

3.2 Input/Output Connections

3.2.01 ac Power Receptacle – This is a 3-prong male plug recessed in the rear panel of the test set. The line cord supplied with the test set supplies ac power to the test set through this connection.

3.2.02 Fuse – The snap-action fuse holder is located just to the left of the ac Power Receptacle. This 2 ampere fuse provides protection to the test set.

3.2.03 115V/230V Switch – On units having serial number 178 and higher this switch provides dual ac power capability.

3.2.04 RECORDER output binding posts –

(1) X provides output proportional to frequency for connection to an xy recorder;

(2) Y provides output proportional to measured data for connection to an xy recorder.

3.2.05 LINE-1, LINE-2, STD – These three pairs of binding posts are used for connection of circuits to be measured. The STD pair may be used to connect a standard for comparison with circuits connected to LINE-1 or LINE-2. Any two pairs may be selected for testing and comparison by pressing the desired COMPARE pushbutton. A dialed-up connection may be held on either LINE-1 or LINE-2 terminals.

3.2.06 EXTERNAL NETWORK – A six-pin connector in parallel with two binding posts is used for connection of a precision network or special network if required to test various types of circuit. The six-pin connector is provided to accept a Wilcom precision network, which is part of the Model T240 Artificial Cable Kit. The build-out capacitor (B.O. CAP) is internally connected across these terminals when D66 or H88 IMPEDANCE COMPENSATOR pushbuttons are not engaged. If not needed, the B.O. CAP should be set at zero.

3.2.07 SEND output binding posts – The T and R terminals allow connection of the internal oscillator's output signal to a circuit under test. GND terminal is used to connect the Level Tracer's chassis ground to the ground of the circuit under test, if required. A dialed-up connection may be held on the SEND terminals.

3.2.08 DIAL Terminals – Two square metal posts allow connection of a lineman's telephone set when it is necessary to dial through the Level Tracer.

3.3 Input Controls

3.3.01 COMPARE: L1/L2, L1/STD, L2/STD – Three pushbuttons having interlocking with lockout action are used to select two inputs for comparison. Pressing L1/L2 will allow LINE-1 and LINE-2 to be connected to the measuring circuits. Pressing L1/STD or L2/STD will allow the corresponding pair of inputs to be connected to the measuring circuits.

NOTE: The actual connection of the selected inputs to the measuring circuits is controlled by the ASSIGN INPUT pushbuttons for the two traces. When the traces are assigned separate inputs, the inputs are alternately connected to the measuring circuits. When both traces are assigned to the same input, that input is continuously connected to the measuring circuit and the other input is open circuited.

3.3.02 LINE-1: HOLD, DIAL – Two pushbuttons with push-push action. Pressing to engage the DIAL pushbutton will connect the LINE-1 terminals to the DIAL posts. When the DIAL pushbutton is released, the LINE-1 terminals are connected to the measuring circuits. When the HOLD pushbutton is engaged, a dialed-up connection will be held.

3.3.03 LINE-2: HOLD, DIAL – Two pushbuttons with push-push action perform the functions of Section 3.3.02 for LINE-2.

NOTE: LINE-1/DIAL and LINE-2/DIAL pushbuttons have a mechanical lockout feature to ensure that only one DIAL pushbutton is engaged at any one time.

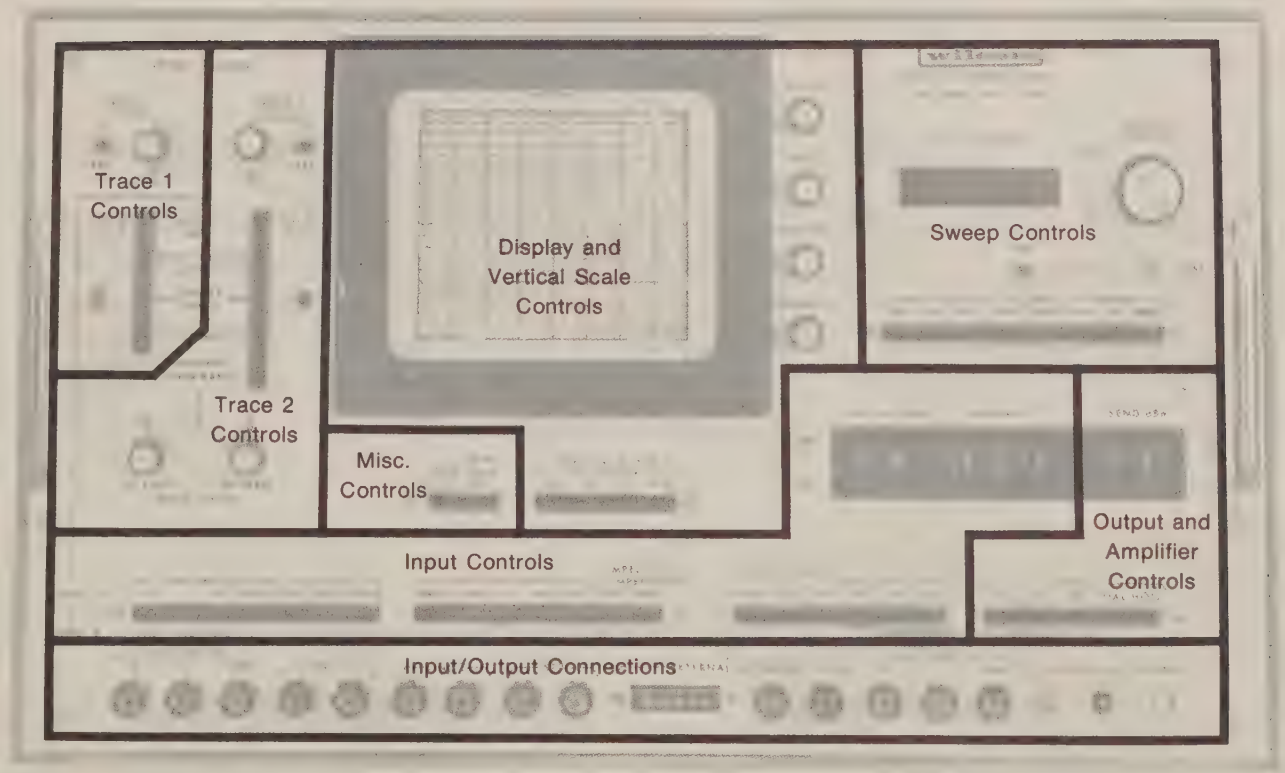


Figure 3-1 Connections and Controls

3.3.04 INPUT IMPEDANCE: BRDG, TERM – Two pushbuttons having interlocking action - when pressed, select either a bridging or terminated input impedance for LEVEL measurements on the LINE-1, LINE-2, and STD input terminals.

3.3.05 INPUT IMPEDANCE: 150, 600, 900 – Three pushbuttons having interlocking action - when pressed, select the input impedance for LEVEL measurements on the LINE-1, LINE-2, and STD input terminals. These pushbuttons do not affect RTN LOSS or IMP measurements.

3.3.06 IMPEDANCE COMPENSATOR: D66, H88 – Two pushbuttons having push-push action. When either pushbutton is engaged the capacitance selected with B.O. CAP uF is connected across the input terminals with an inductor (D66 = 33 mH, H88 = 44 mH) in series between the input terminals and the measuring circuit input. If not needed, the B.O. CAP should be set at zero.

3.3.07 FUNCTION: LEVEL, RTN LOSS, IMP – Three pushbuttons having interlocking with lockout action. When pressed, determines the connections between the input terminals, the measuring circuits and the output amplifier for the type of test to be made.

3.3.08 RET LOSS NET: EXT, 600, 900 – Three pushbuttons having interlocking action. The 600 and 900 buttons, when pressed, select a COMPROMISE NET consisting of 600 or 900 ohms in series with 2.16 uF. The EXT button, when pressed, selects the EXTERNAL NETWORK either the binding posts or the six-pin connector. Schematic detail is shown in the OPERATING INSTRUCTIONS section of the manual.

3.3.09 RECEIVE dBm – This two digit thumbwheel switch establishes the CRT 0dB reference point. When the LEVEL function button is engaged, the thumbwheel setting indicates the level, in dBm, at the zero dB point on the CRT vertical scale. When the RTN LOSS button is engaged, the thumbwheel setting indicates the return loss, in dB at the zero point on the CRT providing the SEND dBm thumbwheel switch is set to 0 dBm. When the IMP button is engaged, the RECEIVE dBm thumbwheel is inoperative.

3.3.10 B.O. CAP uF – This three digit thumbwheel switch sets the value of an internal, step variable, capacitor through a range of 0 to 0.999 uF in 0.001 uF steps. Capacitor location for specific functions is described in sections 3.2.05 and 3.3.06. If not needed, the B.O. CAP should be set at zero.

3.4 Output and Amplifier Controls

3.4.01 SEND: IMPEDANCE, 150, 600, 900 – Three pushbuttons having interlocking action - when pressed, select the output impedance for the SEND terminals. The impedance selection applies only to LEVEL measurements.

3.4.02 SEND: DIAL, HOLD – Two pushbuttons with push-push action perform the functions of Section 3.3.02 for the SEND terminals.

NOTE: The SEND/DIAL pushbutton switch is electrically interlocked with both LINE/DIAL pushbuttons such that when the SEND/DIAL pushbutton is engaged only the SEND terminals may be connected to the DIAL posts.

3.4.03 SEND dBm – This two digit thumbwheel switch sets the signal level applied to the SEND terminals when the LEVEL button is engaged and sets the signal level at which return loss measurements are made when the RTN LOSS button is engaged. When the IMP button is engaged, the SEND dBm must be set at zero for correct impedance readings.

3.5 Sweep Controls

3.5.01 FREQ RANGE Hz: 400, 4K, 8K, 20K – Four pushbuttons having interlocking action. Each pushbutton, when pressed, selects the high end of the frequency range for both the SEND generator and measurement display over the full horizontal CRT scale. Each range starts at 20 Hz.

3.5.02 2600 SKIP – A single pushbutton having push-push action. When engaged, the Level Tracer stops sending when the tuning enters the band between 2450 and 2750 Hz. Any characteristic pattern displayed on frequency ranges of 4K, 8K, or 20K will show a drop-out over this band.

3.5.03 TUNING: MAN, SW, TRACK – Three pushbuttons having interlocking action with lockout. When the MAN button is engaged, the 10 turn knob control designated MANUAL TUNING becomes operative and permits manual adjustment of the SEND frequency. When the SW button is engaged, the tuning is in an automatic sweep mode and will continuously sweep the selected FREQ RANGE Hz measurement range. When the TRACK button is engaged, the tuning control of the Level Tracer will automatically be "locked-on" and track the frequency of an incoming level signal within the limits specified in Section 2.2.11. The 5-digit LED display, SEND FREQUENCY, displays the measurement frequency to which the instrument is presently set via sweep, track, or manual tuning.

3.5.04 SWEEP: SLOW/FAST – A two position toggle switch selects the measurement frequency sweep rate when the SW button is engaged. The sweep rates are approximately 1.5 sec for FAST and 5 sec for SLOW.

3.5.05 0-CAL – A screwdriver adjustment to calibrate the instrument for 0 Hz at the low end of the measurement frequency range.

3.6 TRACE 1 Controls

3.6.01 REF/V-POS – A two position toggle switch, and associated knob control. When the switch is set to REF, the trace is in a fixed vertical position referenced to the vertical scale calibration. When set to V-POS, the position of the trace is controlled by the 270° rotation V-POS knob control.

3.6.02 ASSIGN INPUT: OUT-A, IN-B – A pushbutton having push-push action. Assigns trace 1 to display one of the three inputs as selected by the COMPARE pushbuttons (Section 3.3.01). When engaged, trace 1 will display either L2 or STD; when released, trace 1 will display either L1 or L2.

3.6.03 CONTINUOUS UPDATE – A pushbutton having push-push action. When engaged, the information displayed on trace 1 is continuously updated and the red LED is illuminated to indicate that the information on the next sweep for trace 1 will be stored. If trace 2 is displaying a second COMPARE input, the two traces are updated alternately.

3.6.04 SINGLE UPDATE – A pushbutton having momentary action with interlock to the CONTINUOUS UPDATE button. When pressed, the information from the next single sweep of trace 1 is stored and displayed. The red LED is illuminated until the **beginning** of the sweep that is updating the trace.

3.6.05 CLEAR – A pushbutton having momentary action. When pressed, instantly clears the information stored and displayed for trace 1.

3.7 TRACE 2 Controls

3.7.01 REV/V-POS – A two position toggle switch, and associated knob control. When the switch is set to REF, the trace is in a fixed vertical position referenced to the vertical scale calibration. When set to V-POS, the position of the trace is controlled by the 270° rotation V-POS knob control.

3.7.02 ASSIGN INPUT: OUT-B, IN-A – A pushbutton having push-push action. Assigns trace 2 to display one of the three inputs as selected by the COMPARE pushbuttons (Section 3.3.01). When engaged, trace 2 will display either L1 or L2; when released, trace 2 will display either L2 or STD.

3.7.03 CONTINUOUS UPDATE – A pushbutton having push-push action. When engaged, the information displayed on trace 2 is continuously updated and the red LED is illuminated to indicate that the information on the next sweep for trace 2 will be stored. If trace 1 is displaying a second COMPARE input, the two traces are updated alternately.

3.7.04 SINGLE UPDATE – A pushbutton having momentary action with interlock to the CONTINUOUS UPDATE button. When pressed, the information from the next single sweep of trace 2 is stored and displayed. The red LED is illuminated until the **beginning** of the sweep that is updating the trace.

3.7.05 CLEAR – A pushbutton having momentary action. When pressed, instantly clears the information stored and displayed for trace 2.

3.7.06 AVERAGE OVER BAND – A pushbutton having push-push action. When engaged, information displayed on trace 2 is averaged over a frequency band set by the LO FREQ and HI FREQ controls for BAND LIMITS. A straight horizontal line will be displayed representing the average value for the selected portion of the characteristic being measured.

3.7.07 BAND LIMITS: LO FREQ, HI FREQ – Two knob controls having 270° rotation. When the AVERAGE OVER BAND pushbutton is engaged, set the frequency band limits for the average function.

3.8 Display and Vertical Scale Controls

3.8.01 FOCUS – A knob having 270° rotation. Used in conjunction with the ASTIG control to obtain a well-defined display. Adjust for minimum trace width.

3.8.02 ASTIG – A knob having 270° rotation. Used in conjunction with the FOCUS control to obtain a well-defined display. Adjust for equal focus of horizontal and vertical segments of display.

3.8.03 HOR POS – A knob having 270° rotation. Provides control of the horizontal position of the display.

3.8.04 INTENSITY – A knob having 270° rotation. Controls the brightness of the display.

3.8.05 VERTICAL SCALE MULTIPLIER: X1, X2, X5, X10 – Four pushbuttons having interlocking action with lockout. Select the CRT vertical deflection scale factor. When the X1 pushbutton is engaged, the vertical scale values are read directly from the graticule. When the X2, X5, or X10 pushbutton is engaged, the vertical scale values are multiplied by the corresponding factor.

3.9 Miscellaneous Controls

3.9.01 FREQ MARK – A pushbutton having push-push action. When engaged, a frequency marker appears on both traces in the form of a short vertical line. The marker indicates the SEND frequency with respect to the graticule horizontal scale. By using manual send tuning, the marker can be positioned at any point on a stored trace and the corresponding frequency read from the SEND FREQUENCY digital display.

3.9.02 LOW FREQ REJ – A pushbutton having push-push action. When engaged, the instrument's low frequency response is attenuated to reject 60 Hz hum interference.

4.0 OPERATING INSTRUCTIONS

4.1 General

4.1.01 For operation, connect the line cord, supplied with the test set, to the recessed male connector on the rear panel. Set the voltage slide switch to either 115V or 230V position depending on the line voltage which will be used. The other end of the cord may be plugged into any 115 or 230 volt three-wire convenience outlet. Power is supplied to the test set by pushing the POWER pushbutton. The integral lamp indicates that power is being supplied to the test set.

4.1.02 After power has been applied, the set will be ready to use as soon as the cathode ray tube display is visible. The frequency calibration may drift for a short period, particularly if the set has been stored in a cold environment for some time. Ample time should elapse to allow the set to warm-up before the 0 CAL control is adjusted in accordance with 4.2.01. No other calibration is required.

4.2 Initial Conditions

4.2.01 During initial familiarization with the Level Tracer, all switches and controls should first be set to the following positions. The operating instructions of this section assume these initial conditions have been established.

1. Set all controls as follows:

TRACE 1 & 2: toggle switches	REF
TRACE 1 & 2: ASSIGN INPUT	Engaged
TRACE 1 & 2: CONTINUOUS UPDATE	Engaged
TRACE 2 AVERAGE OVER BAND	Released
COMPARE: L1/L2	Engaged
LINE 1 & 2: HOLD	Released
LINE 1 & 2: DIAL	Released
INPUT IMPEDANCE: TERM	Engaged
INPUT IMPEDANCE: 600	Engaged
IMPEDANCE COMPENSATOR: D66 &	Released
H88 FUNCTION: LEVEL	Engaged
RET LOSS NET: 600	Engaged
SEND IMPEDANCE: 600	Engaged
SEND: DIAL	Released
SEND: HOLD	Released
FREQ RANGE Hz: 8K	Engaged
2600 SKIP	Released
TUNING: SW	Engaged
SWEEP: SLOW/FAST	FAST
RECEIVE dBm	00
B.O. CAP uF	000
SEND dBm	00
VERTICAL SCALE MULTIPLIER: X10	Engaged
LOW FREQ REJ	Released
FREQ MARK	Engaged

NOTE: Pushbuttons having interlocking action with any shown "engaged" in the above list will be in the released position.

2. Install patch cord between LINE-1 and SEND terminals.
3. Adjust the INTENSITY, FOCUS, and ASTIG knobs for a well defined trace along the zero dB reference line. The input relay switching between traces should be audible.
4. After warm-up, calibrate the HOR POS as follows:
   a. Engage the TUNING: MAN pushbutton and turn the MANUAL TUNING knob fully counterclockwise.
   b. Adjust the screwdriver 0-CAL control for zero SEND FREQUENCY.
   c. Adjust the MANUAL TUNING knob for a SEND FREQUENCY of 4000 Hz.
   d. Adjust the HOR POS knob to center the frequency marker.
5. Engage the TUNING: SW pushbutton.
6. Engage FREQ RANGE Hz: 20K pushbutton.

4.3 Dial and Hold

4.3.01 To dial and hold a line:

1. Press to engage the DIAL pushbutton associated with the Level Tracer terminals in use.
2. Connect a lineman's test telephone to the dial posts and dial the required test number.
3. After reaching the test number, push to engage the HOLD pushbutton associated with the terminals in use.
4. Push to release the DIAL pushbutton.
5. The connection will now be held until dropped by pushing to release the HOLD pushbutton.

4.4 Sending Tones

4.4.01 The internal signal generator will provide either a manually adjustable or an automatic sweeping signal to a circuit under test.

4.4.02 A single frequency, non-sweeping signal is sent as follows:

1. Press to engage the TUNING: MAN pushbutton.
2. Press to engage the lowest frequency FREQ RANGE Hz pushbutton that is above the desired signal frequency. (A higher frequency range may be used with a loss in tuning sensitivity).
3. Adjust the MANUAL TUNING knob until the desired signal frequency is displayed as SEND FREQUENCY.
4. Push to engage the desired SEND IMPEDANCE pushbutton.
5. Adjust the two digit SEND dBm thumbwheel switch to display the desired signal level.

6. Verify the FUNCTION: LEVEL pushbutton is engaged.

7. The desired signal frequency and level is now present at the SEND terminals for connection to the circuit being tested.

4.4.03 An automatic sweeping signal is sent as follows:

1. Press to engage the TUNING: SW pushbutton.

2. Press to engage the FREQ RANGE Hz pushbutton to select the high frequency end of the sweep frequency range.

3. Select the desired sweep speed with the SWEEP: SLOW/FAST toggle switch.

4. Push to engage the desired SEND IMPEDANCE pushbutton.

5. Adjust the two digit SEND dBm thumbwheel switch to the desired signal level.

6. Verify the FUNCTION: LEVEL pushbutton is engaged.

7. The sweeping signal of selected range and level is now present at the SEND terminals for connection to the circuit being tested.

4.5 CRT Trace Display

4.5.01 The tuning controls for the internal generator also control the horizontal sweep of the CRT. The engaged FREQ RANGE Hz pushbutton determines the horizontal frequency scale while the horizontal position of the trace sweep is determined by the internal generator tuning (displayed as SEND FREQUENCY). When the TUNING: MAN pushbutton is engaged, the position of the sweep is controlled by the MANUAL TUNING knob - the internal generator must be manually tuned to sweep and update the CRT traces. When the TUNING: SW pushbutton is engaged, the internal generator automatic tuning also controls the CRT sweep. When the TUNING: TRACK pushbutton is engaged, an external signal must be applied to a measure input to control the internal tuning of the Level Tracer.

4.5.02 The CRT graticule scales are calibrated for direct reading of dB values or impedance values when the VERTICAL SCALE MULTIPLIER: X1 pushbutton is engaged - each vertical division is either 0.2 dB or 50 ohms. When either the X2 or X5 or X10 pushbutton is engaged, the vertical measurement display range is increased by the corresponding factor.

4.6 Line Selections and Updating the Display Traces

4.6.01 The two CRT traces (TRACE 1, TRACE 2) may be assigned, either simultaneously or individually, to display any two of the three measuring inputs (LINE-1, LINE-2, STD) and may be updated on successive sweeps or on an individual sweep basis.

4.6.02 The three COMPARE and two ASSIGN INPUT pushbuttons provide the means for selecting any two of the three measure inputs (Section 3.2.04) for storage and display on the CRT. When the trace 1 ASSIGN INPUT pushbutton (designated OUT-A, IN-B) is engaged, INPUT B is selected. This will connect, as determined by the engaged COMPARE pushbutton, either the L2 or STD input to the trace 1 storage and display. When the trace 1 ASSIGN INPUT pushbutton is released, INPUT A is selected and either the L1 or L2 input is connected to trace 1. The trace 2 ASSIGN INPUT pushbutton (designated OUT-B, IN-A) works in a similar manner to connect the selected measure input to the trace 2 storage and display.

4.6.03 When the TUNING: SW pushbutton is engaged, the updating of stored and displayed information is controlled by the CONTINUOUS UPDATE and SINGLE UPDATE pushbuttons for each trace. When the CONTINUOUS UPDATE pushbutton for only one trace is engaged, that trace will be updated every time the CRT is swept. When both CONTINUOUS UPDATE pushbuttons are engaged, and the traces are assigned to separate inputs, each trace will be updated on alternate sweeps of the CRT. If both traces are assigned to the same input, both traces will be updated every time the CRT is swept. Pushing the SINGLE UPDATE pushbutton will cause the corresponding trace to be updated on the next sweep and will release the CONTINUOUS UPDATE button for that trace. When the red light next to the button goes out, information is being stored and displayed for the corresponding trace and will not change until an UPDATE pushbutton for that trace is again pressed.

4.6.04 When either the TUNING: TRACK or the TUNING: MAN pushbutton is engaged, only one trace may be selected for CONTINUOUS UPDATE. If both CONTINUOUS UPDATE pushbuttons are engaged, only trace 1 will be continuously updated - the trace 1 CONTINUOUS UPDATE must be released before the trace 2 CONTINUOUS UPDATE will be electrically activated. During TRACK or MAN operation the SINGLE UPDATE function is not operational because there are no sweep control signals available to control any single update.

4.6.05 Pushing either trace CLEAR pushbutton will instantly remove the stored and displayed information for the corresponding trace. The next sweep of the generator will store and display the measured characteristic if the CONTINUOUS UPDATE pushbutton is engaged.

4.6.06 Other trace controls are discussed in separate sections: V-POS/REF - Section 4.5; AVERAGE OVER BAND - Section 4.11.

4.7 Test Selection

4.7.01 The FUNCTION pushbuttons are used to select the type of testing operation to be performed. Push to engage LEVEL, RTN LOSS, or IMP. Other controls are then used to set up the instrument for the specific test operation. Detailed applications instructions are provided in Section 5.0 of the Applications Manual for specific test operations.

4.8 Level Measurements (LEVEL)

4.8.01 See Section 4.3 to dial and hold a line for LEVEL measurements.

4.8.02 Push to engage the FUNCTION: LEVEL pushbutton. Verify that the DIAL and IMPEDANCE COMPENSATOR pushbuttons are released and that both trace V-POS/REF toggle switches are in the REF position.

4.8.03 Referring to Section 4.6, select the measure inputs being used and assign traces for display.

4.8.04 The INPUT IMPEDANCE pushbuttons select either BRDG or TERM plus an appropriate impedance value (150, 600, or 900 ohms) for receiving/measuring on any circuit connected through the measure input connectors and line select and trace assign switches to the measuring circuits input.

4.8.05 The RECEIVE dBm thumbwheel switches determine the attenuation imposed on a signal being measured by the Level Tracer and indicate the level at 0 dB on the CRT vertical scale. These switches have no effect when the IMP function is selected.

4.8.06 The FREQ RANGE Hz pushbuttons determine the frequency range over which the measurement will be displayed, as well as the range of SEND frequency tuning.

4.8.07 When using the Level Tracer to make circuit loss (or gain) measurements, the test signal may be obtained from the Level Tracer's internal generator or from an external source. However, when using an external source or the internal generator in other than SWEEP Tuning mode, the user should be aware of the following operating principles:

1. The information stored and displayed represents the broad-band received signal level vertically, and the internal generator frequency at the time information was stored horizontally. The Level Tracer is not a spectrum analyzer.

2. A change in generator frequency is required to effect any entry of data into trace storage.

3. When the internal generator is used (see Section 4.4) it is normally set in SWEEP tuning mode. If the internal generator is in MAN and is set to a fixed frequency, no updating will occur. Now, if the manual tuning knob is turned, new data on the trace set for continuous update begin to appear as the send frequency changes.

4. When an external sweep generator is used, the internal generator should be set in TRACK tuning mode. The internal frequency will now track the received frequency and updating will take place as required.

5. When an external fixed frequency source is used, the internal generator should first be set in SWEEP tuning mode. Since the received level remains unchanged as the internal frequency sweeps, the trace will be a horizontal line across the screen. The received level is read from the trace position. Now switch the internal generator to TRACK mode. It will lock on to the received frequency, which can be read on the digital SEND FREQUENCY display.

4.8.08 Other controls (such as LOW FREQ REJ, VERTICAL SCALE MULTIPLIER, and V-POS/REF) that may also be useful in level tests are described separately in this section.

4.9 Impedance Measurements (IMP)

4.9.01 The Level Tracer generator is used internally for impedance measurements and is therefore not available at the SEND terminals when the FUNCTION: IMP pushbutton is engaged (FIG 4.1). TUNING may be either SW or MAN. The FREQ RANGE Hz pushbuttons determine the frequency range over which the measurement will be displayed.

4.9.02 Verify that the DIAL and IMPEDANCE COMPENSATOR pushbuttons are released and that both trace V-POS/REF toggle switches are in the REF position.

4.9.03 Referring to Section 4.6, select the measure inputs being used and assign traces for display.

4.9.04 The SEND dBm thumbwheel switches are normally set at 0 dBm for correct vertical CRT scaling to allow direct reading of impedance from the calibrated graticule. However, in certain cases it is useful to set the SEND dBm thumbwheel switches for other than 0 dBm to get better resolution of very low value impedances or extend the range for high value impedances. In such cases, impedance values can be obtained by reducing the reading determined from the CRT screen by the SEND dBm switch setting expressed as a ratio with respect to 0 dBm. This calculation is illustrated in the following examples:

Impedance Example 1

SEND dBm setting: +18 dBm = ratio of 8.1

CRT graticule impedance times VERTICAL SCALE MULTIPLIER = 100 ohms

Calculated value: 100 ohms ÷ 8 = 12 ohms

NOTE: When measuring low impedance values, the 3 percent of vertical scale accuracy specification will become a significant portion of the measured value.

Impedance Example 2

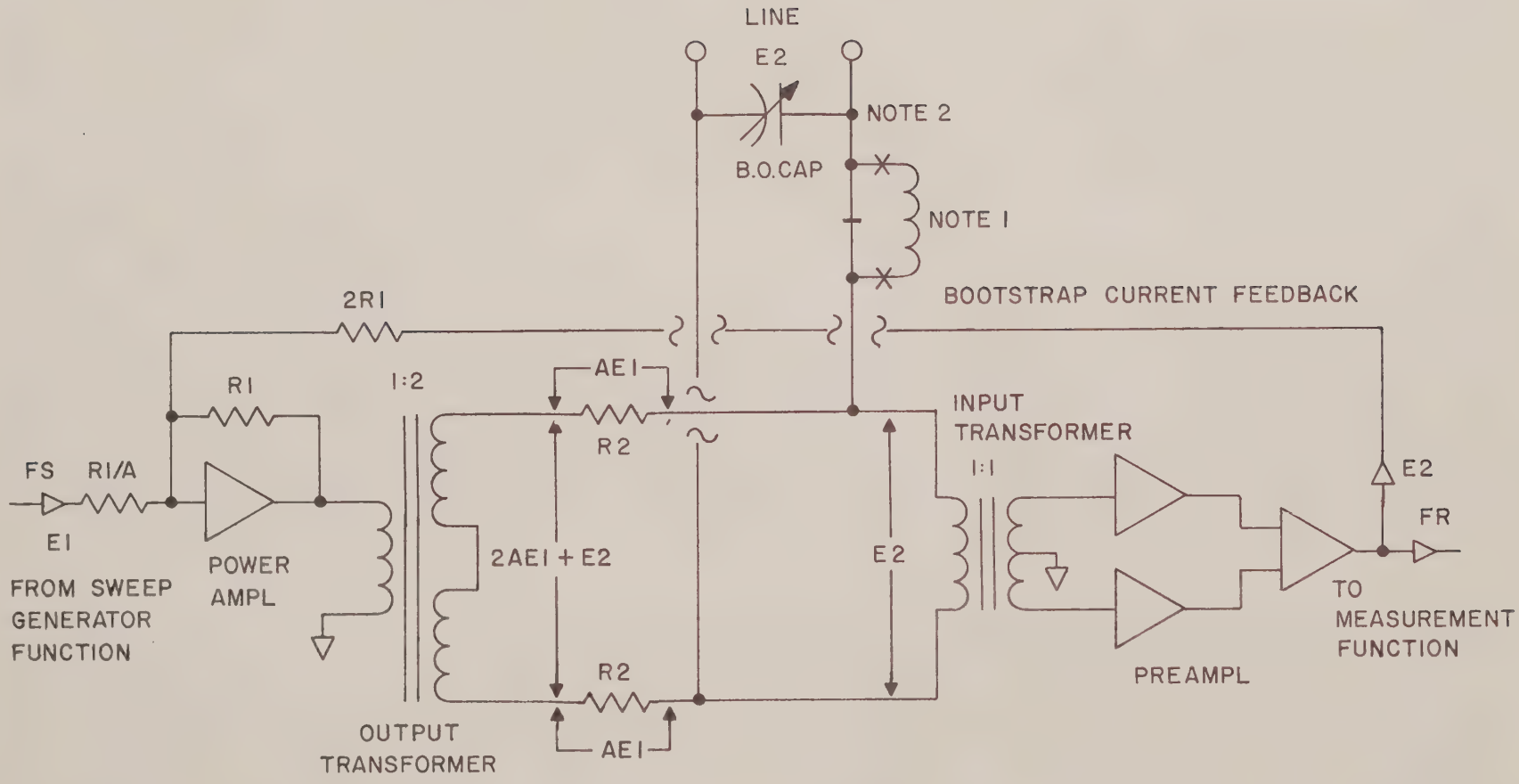
SEND dBm setting: −6 dBm = ratio of 0.5:1

CRT graticule impedance times VERTICAL SCALE MULTIPLIER = 7000 ohms

Calculated value: 7000 ohms ÷ 0.5 = 14,000 ohms

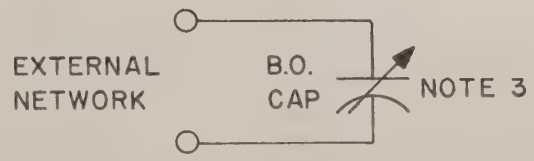
NOTE: When expanding the measurement range above 10,000 ohms, input circuit loading will increasingly become a factor in the results with higher impedance and frequency.

4.9.05 Detailed applications instructions are provided in Section 5.0 of the Applications Manual for using the IMPEDANCE COMPENSATOR for cable measurements or the B.O. CAP for capacitance measurements with the impedance function. Other controls (such as LOW FREQ REJ, VERTICAL SCALE MULTIPLIER, and



NOTES

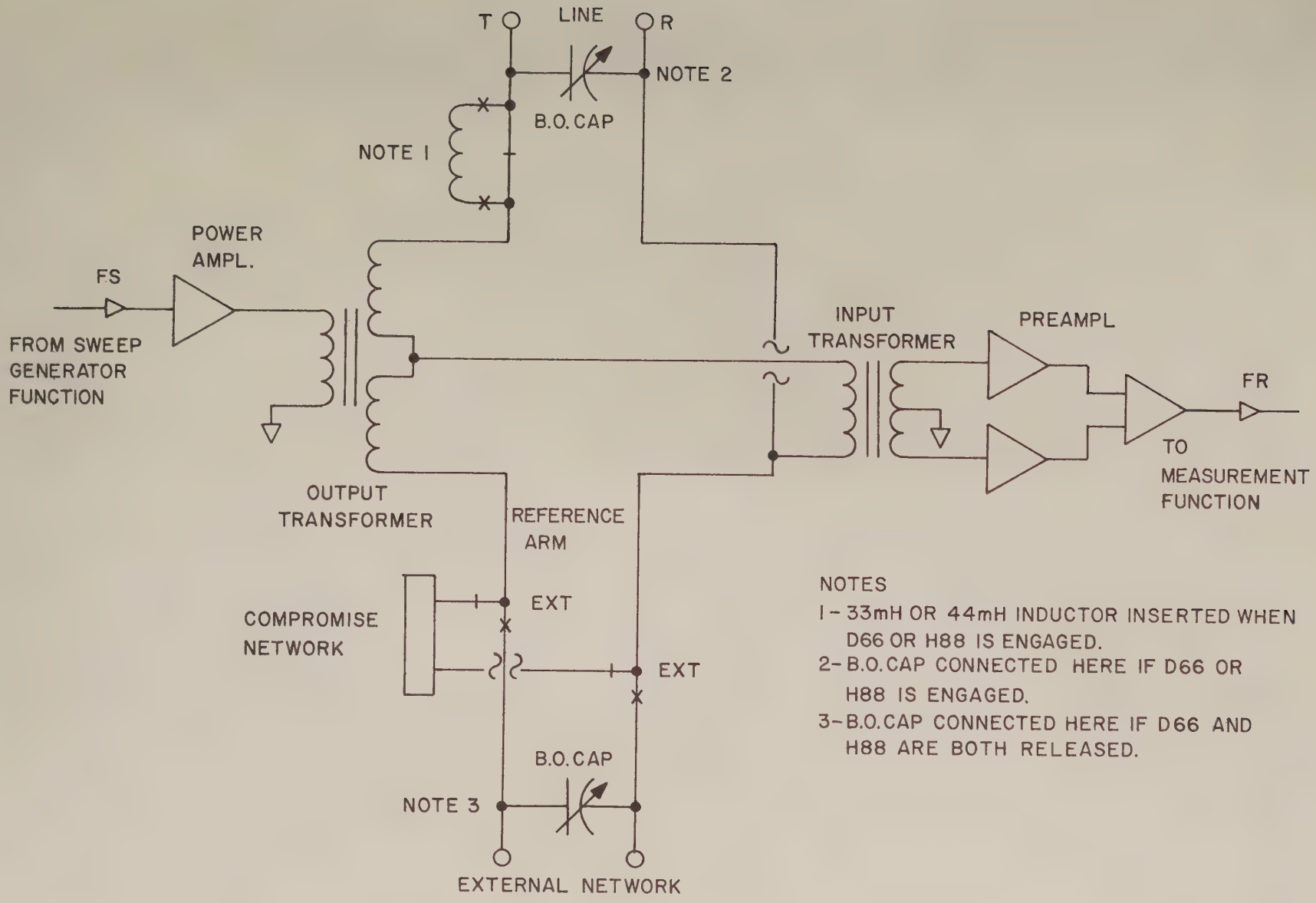
1- 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.
2- B.O.CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.
3- B.O.CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.



$$E2 = (2AE1 + E2)\frac{Z_{LINE}}{Z_{LINE} + 2R_2} = AE_1\frac{Z_{LINE}}{R_2}$$

BLOCK DIAGRAM - IMPEDANCE TEST

FIG. 4-1



NOTES

1 - 33mH OR 44mH INDUCTOR INSERTED WHEN D66 OR H88 IS ENGAGED.

2 - B.O.CAP CONNECTED HERE IF D66 OR H88 IS ENGAGED.

3 - B.O.CAP CONNECTED HERE IF D66 AND H88 ARE BOTH RELEASED.

Block Diagram - Return Loss Test

Fig. 4-2

AVERAGE OVER BAND) that may also be useful in impedance tests are described separately in this section.

4.10 Return Loss Measurements (RET LOSS)

4.10.01 The Level Tracer generator is used internally for return loss measurements and is therefore not available at the SEND terminals when the FUNCTION: RTN LOSS pushbutton is engaged (FIG 4.2). TUNING may be either SW or MAN. The FREQ RANGE Hz pushbuttons determine the frequency range over which the measurement will be displayed.

4.10.02 Verify that the DIAL and IMPEDANCE COMPENSATOR pushbuttons are released and that both trace V-POS/REF toggle switches are in the REF position.

4.10.03 Referring to Section 4.6, select the measure inputs being used and assign traces for display.

4.10.04 The reference against which the return loss is measured is selected by engaging one of the three RET LOSS NET pushbuttons (SECTION 3.3.08). Since internal switching places the B.O. CAP across the INTERNAL NETWORK terminals when both IMPEDANCE COMPENSATOR pushbuttons are released, the B.O. CAP may be used as all or part of the reference. When not needed, the B.O. CAP thumbwheel switches should be set at zero.

4.10.05 Normally, when the FUNCTION: RTN LOSS pushbutton is engaged, the SEND dBm thumbwheel switches are set to zero. The 0 dB point on the graticule is then a calibrated reference line as determined by the setting of the RECEIVE dBm thumbwheel switches. The return loss is the algebraic sum of the RECEIVE dBm thumbwheel switch setting and the deflection in dB (including VERTICAL SCALE MULTIPLIER) of the CRT trace from the 0 dB reference line, with the sign reversed. (More negative received level represents more positive return loss.)

4.10.06 In certain cases it may be useful to set the SEND dBm thumbwheel switches for other than 0 dBm. This can be helpful when measuring large return loss values or when the instrument is used for comparison bridge measurements as described in the Applications Manual. The return loss is then determined by algebraically summing the RECEIVE dBm setting with the value determined from the screen, reversing the sign, and then adding the SEND dBm setting.

4.10.07 Two typical return loss calculations are illustrated in the following examples.

Return Loss Example 1

RECEIVE dBm setting = −20 dB

CRT trace deflection from 0 dB graticule times VERTICAL SCALE MULTIPLIER = −5 dB

SEND dBm setting = 0

Calculated value: $-[(-20)+(-5)]+(0) = 25$ dB

Return Loss Example 2

RECEIVE dBm setting = −30 dB

CRT trace deflection from 0 dB graticule times VERTICAL SCALE MULTIPLIER = −5 dB

SEND dBm setting = +5 dB

Calculated value: $-[(-30)+(-5)]+(+5) = 40$ dB

4.10.08 Other controls (such as LOW FREQ REJ, VERTICAL SCALE MULTIPLIER, and AVERAGE OVER BAND) that may also be useful in Return Loss measurements are described separately in this section.

4.11 AVERAGE OVER BAND Function

4.11.01 The AVERAGE OVER BAND pushbutton (Section 3.7.06) is usually engaged only for impedance and return loss measurements. The LO FREQ and HI FREQ controls set the low and high limits over which the average measured value is displayed as a straight line. When averaging a portion of the CRT display the TUNING: MAN pushbutton may be engaged and the desired band limits frequencies set using the frequency marker position and the displayed SEND FREQUENCY.

4.12 LOW FREQ REJ Function

4.12.01 The LOW FREQ REJ pushbutton (Section 3.9.02) may be engaged during any of the Level Tracer measurement functions to reduce the effect of low frequency noise on the characteristic being displayed. The function is particularly useful when measuring low signal levels or high return loss levels with high levels of 60 Hz induced noise.

5.0 APPLICATIONS

5.1 General

5.1.01 After the power cord has been connected and the power turned on in accordance with the instructions in Section 4.1.01, the set will be ready to use as soon as the cathode ray tube display is visible. The frequency calibration may drift slightly for a short period, particularly if the set has been stored in a cold environment for some time. Ample time should elapse to allow the set to warm up before the O CAL control is adjusted in accordance with 4.2.01. No other calibration is required.

5.1.02 Connections to the set, the selection of the lines under test, and the display updating procedure should be selected on the basis of information supplied in Sections 3.0 and 4.0.

5.1.03 Be sure DIAL buttons are **not** depressed except as required for dialing to another office. Depressing these buttons will disconnect the set functions from the LINE and SEND binding posts.

5.2 Impedance Measurements

5.2.01 The impedance characteristic of a loaded cable pair appears as a series of peaks and valleys. When no faults exist on the cable, the characteristic has a uniformly varying pattern. Fault conditions will show significant deviations from normal. Methods for analyzing these faults will be reviewed in subsequent sections.

5.2.02 One observation that may prove useful is the difference between a short circuited or open circuited impedance characteristic. If both are displayed, they should be exactly 180° out of phase with respect to one another. If both patterns are not available, it is usually possible to determine the nature of the condition by observing the start of the trace. When a 4 kHz sweep is used, the region up to 500 Hz will show a pattern which starts at the top and sweeps downward when the pair is open circuited. When a short circuit exists this region usually shows the sweep going upward. This becomes more obvious when a 400 Hz sweep is used. These observations can be made on cables with up to 12 loaded sections.

a. Push IMP button under FUNCTION.

b. Select desired frequency range (usually 4 kHz).

c. Set SEND dBm switch to 0.

d. Push SW button under TUNING.

e. Set VERTICAL SCALE MULTIPLIER to X5. After impedance characteristic is displayed, set the multiplier to whatever range provides the best range of display for the test.

f. Be sure both IMPEDANCE COMPENSATOR buttons are released (out).

5.3 Impedance Measurements with Precision Network Termination

5.3.01 It is frequently desirable to terminate a cable pair in a precision network and a capacitor to determine if the impedance curve is smooth over the selected frequency range. If the curve is not smooth, cable faults are indicated.

a. Connect the cable pair to be tested to LINE 1 binding posts.

b. Connect an artificial cable pair that simulates the makeup of the cable pair to be tested to LINE 2 binding posts.

c. Connect the appropriate precision network and a build-out capacitor to the far end of the artificial cable pair.

d. Follow steps a through f of 5.2.

e. Push the L1 - L2 button under COMPARE.

f. Assign the input so Line 1 appears on Trace 1 and Line 2 appears on Trace 2.

g. Adjust the build-out capacitor on the artificial line until the pattern on Trace 2 is smooth over the normal frequency band for the pair.

h. Connect a precision network to the far end of the actual cable pair to be tested and add a build-out capacitor of the same value selected for the artificial cable pair.

i. The characteristic displayed on Trace 1 should be the same as for the artificial line on Trace 2. Significant deviations will indicate the presence of a fault. Interpretations of these deviations will be discussed in a subsequent section of the manual.

5.4 Impedance Measurement With Impedance Compensator

5.4.01 The impedance characteristic displayed in the test outlined in 5.3 can be flattened out by adding an impedance compensator and build-out capacitor at the T195 end of the line under test. It is frequently desirable to use this approach to simplify analyzing the faults which may be indicated.

a. Follow steps a through h of 5.3

b. Press the appropriate IMPEDANCE COMPENSATOR button for the loading used.

c. Adjust the BO CAP until the characteristic of the artificial cable displayed on the screen is flat with a smooth roll off at the high frequency end.

d. The characteristic of the line under test on Trace 1 should be the same as that of the artificial line. Significant deviations will indicate the presence of a fault.

5.5 Capacitance Measurements

5.5.01 The capacitance measurement technique described below is to be used on capacitors only and should not be used on circuits with inductive components such as a loaded cable. Tests on loaded cable are described in a subsequent section.

5.5.02 Comparison Method

a. Connect the capacitance to be measured to Line 1.

b. Connect the EXTERNAL NETWORK binding posts to Line 2.

c. Assign Line 1 to Trace 1 and Line 2 to Trace 2.

d. Push CONTINUOUS UPDATE buttons for both traces.

e. Set VERTICAL SCALE MULTIPLIER at X10.

f. Set SEND attenuator at 0 dBm.

g. Push FUNCTION - IMP button.

h. Set TUNING at SW.

i. Be sure the IMPEDANCE COMPENSATOR buttons are released.

j. Set FREQ RANGE for the capacitance range to be measured in accordance with the following chart.

Capacitance Range	Freq. Range
.001 - .005 uf	20 kHz
.005 - .02	8
.02 - .10	4
.10 - .999	400 Hz

k. The pattern appearing on Trace 1 represents the reactance curve of the capacitor under test. Once the pattern has been established, store this curve for continuous display by pushing the SINGLE UPDATE button once for Trace 1.

l. Increase the value of the B.O. CAP starting from 0 uf until a reactance curve for this capacitor appears on Trace 2. Increase the B.O. CAP until the two curves on Traces 1 and 2 are conincident. The value of the B.O. CAP then represents the capacitance of the capacitor under test.

5.5.03 Return Loss Method – This method of determining the capacitor is comparable to a bridge type measurement and is quite sensitive.

a. Connect the capacitance to be measured to Line 1.

b. Assign Line 1 to Trace 1.

c. Push the CONTINUOUS UPDATE button for Trace 1 and the SINGLE UPDATE button for Trace 2.

d. Set VERTICAL SCALE MULTIPLIER at X10.

e. Set SEND attenuator at 0 dBm.

f. Push FUNCTION - RTN LOSS button.

g. Push EXT button under RET LOSS NET.

h. Set TUNING at SW.

i. Set FREQ RANGE at 4K.

j. Set RECEIVE attenuator at 0 or −10 dBm, whichever setting will show a pattern on the screen.

k. Be sure the IMPEDANCE COMPENSATOR buttons are released.

l. Increase the B.O. CAP from 0 and note the postion of the pattern. As capacitance is increased the pattern should move downward. As the pattern nears the bottom of the graticule, it may be necessary to change the RECEIVE attenuator to −30 dBm.

m. As a minimum position of the trace is approached, the incremental changes in the value of the B.O. CAP should be as small as possible. When a minimum position is reached, the B.O. CAP will read the value of the capacitance under test.

5.6 Resistance Measurements

5.6.01 Two methods of measuring resistance may be used. One method is to make an impedance measurement and the second method is using the return loss technique which compares the resistance under test with a calibrated variable resistor. The second method is the more accurate.

5.6.03 Impedance Measurement Method

a. Connect the resistor to be measured to Line 1.

b. Follow steps a through f of 5.2.

c. Read the impedance on the vertical scale on the right side of the graticule and multiply by the VERTICAL SCALE MULTIPLIER that has been selected.

5.6.03 Return Loss Method

a. Connect resistor to be measured to Line 1.

b. Push RTN LOSS button under FUNCTION.

c. Push the 400 button under FREQUENCY RANGE.

d. Set SEND dBm switch to 0.

e. Push SW button under TUNING.

f. Push X10 button under VERTICAL SCALE MULTIPLIER.

g. Be sure both IMPEDANCE COMPENSATOR buttons are released (out).

h. Push EXT button under RET LOSS NET and set the B.O. CAP switch at 0 uf.

i. Connect a resistance decade box with sufficient resistance decades to measure the resistance with the desired accuracy, to the EXT binding posts.

j. Set the RECEIVE dBm switch to −10 or −20 dBm as required to see the pattern.

k. Assign the input so Line 1 is connected to Trace 1.

l. Push the CONTINUOUS UPDATE button for Trace 1.

m. Vary the resistance of the decade box until the display reaches the maximum downward vertical deflection. It may be necessary to set the RECEIVE dBm switch to −30 dBm to see the maximum downward deflection as the various decades of the resistance box are adjusted. The resistance reading of the decade box for the maximum downward deflection represents the resistance of the resistor under test.

5.7 Determining Length of Cable

5.7.01 The length of a cable may be determined by open circuit and short circuit measurements. These techniques may also be used to determine the distance to an open or short circuit at any point along the length of the cable. Different techniques are preferred for non-loaded and loaded cables. These will be reviewed in subsequent sections.

5.7.02 Open Circuit Measurement - Capacitance Comparison Method: This method requires that the far end of the cable pair be open.

a. Connect the cable pair to the Line 1 binding posts.

b. Connect the EXTERNAL NETWORK binding posts to the Line 2 binding posts.

c. Assign Line 1 to Trace 1 and Line 2 to Trace 2.

d. Push CONTINUOUS UPDATE buttons for both traces.

e. Set VERTICAL SCALE MULTIPLIER to X10.

f. Set SEND attenuator at 0 dBm.

g. Push FUNCTION - IMP button.

h. Be sure the IMPEDANCE COMPENSATOR buttons are released.

i. Set TUNING at SW.

j. Set FREQ RANGE as follows:

Non-loaded Cable

Non-loaded cable can be checked in a similar manner to making capacitance measurements as outlined in sections 5.5.02 k. Short sections of cable probably would not have a capacitance of less than .02 uf so the frequency range can be set for up to 4 kHz. For lengths exceeding .1 uf, the 400 Hz range should be used.

Loaded Cable

Loaded cables include inductive components which affect the impedance characteristic in most instances above 150 Hz. Consequently, the FREQ RANGE Must be set for 400 Hz for this test.

k. The pattern appearing on Trace 1 represents the reactance curve of the capacitance of the cable pair under test. Once this pattern has been established, store this curve for continuous display by pushing the SINGLE UPDATE button once for Trace 1.

l. Increase the value of the B.O. CAP starting at 0, preferably in steps of .1 uf until a reactance curve for this capacitor appears on Trace 2. Increase the B.O. CAP until the two curves on Traces 1 and 2 are coincident. Smaller increments of capacitance changes should be used as coincidence is approached.

m. If cable lengths which have a capacitance in excess of .999 uf are to be measured, a known value of capacitance should be connected across the EXTERNAL NETWORK binding posts.

n. On loaded cables, the range of coincidence will be different for different numbers of load coils as follows:

Number of load coils	Coincidence up to	Vertical Scale Multiplier
up to 8	150 Hz	X10
9-11	100	X10
11-13	70	X10
13-18	50	X 5

o. The value of the B.O. CAP used at coincidence represents the capacitance of the cable pair under test. By dividing this value by the capacitance per unit lenth of the cable, the length of the cable pair can be determined. Nominal per unit length values are used, so a good approximation of length can be made. However, manufacturing tolerances and temperature effects will affect the accuracy of the measurement.

NOTE: When the length of a loaded cable is determined, the capacitance introduced by the load coils must be taken into account. This can be in the vicinity of .0048 uf per coil. The capacitance per coil times the number of coils must be subtracted from the measured capacitance to determine the actual capacitance of the cable.

5.7.03 Open Circuit Measurement - Return Loss Method: This method also requires that the far end of the cable pair is open. It is a little more difficult to make this test with loaded cable but it works satisfactorily on non-loaded cable.

a. Connect the cable pair to the Line 1 binding posts.

b. Assign Line 1 to Trace 1.

c. Push the CONTINUOUS UPDATE button for Trace 1 and the SINGLE UPDATE button for Trace 2.

d. Set VERTICAL SCALE MULTIPLIER at X10.

e. Set SEND attenuator at 0 dBm.

f. Push FUNCTION - RTN LOSS button.

g. Push EXT button under RET LOSS NET.

h. Set TUNING at SW.

i. Set FREQ RANGE at 400.

j. Set RECEIVE attenuator at 0 or −10 dBm, whichever setting will show a pattern on the screen.

k. Be sure the IMPEDANCE COMPENSATOR buttons are released.

l. Increase the B.O. CAP from 0 and note the position of the pattern in the vicinity of 50 Hz on the graticule. As capacitance is increased the pattern should move downward.

m. On **loaded** cable there may be little change in the pattern above 60 Hz.

n. On **non-loaded** cable the whole pattern will move downward.

o. As the capacitance is changed it may be necessary to change the RECEIVE attenuator to −20 dBm and then −30 dBm.

p. As a minimum position of the area of concern on the trace is approached, the incremental changes in the value of the B.O. CAP should be smaller. When a minimum position is reached, the B.O. CAP will read the value of the capacitance of the cable pair under test. This minimum is easily observed on non-loaded cable, but may be difficult to detect on a loaded cable. By dividing the value of the measured capacitance by the capacitance per unit length, the length of the cable pair can be determined.

5.7.04 Short Circuit Measurement - Resistance Comparison Method: This method requires that the cable pair be short circuited at the far end. The accuracy of these tests will be affected by cable manufacturing tolerance and temperature effects.

a. Connect the short circuited cable pair to be tested to the Line 1 binding posts.

b. Push the RTN LOSS button under FUNCTION.

c. Push the 400 button under FREQ RANGE.

d. Push SW button under TUNING.

e. Set SEND dBm switch on 0.

f. Push X10 button under VERTICAL SCALE MULTIPLIER.

g. Be sure both IMPEDANCE COMPENSATOR buttons are released.

h. Push EXT button under RET LOSS NET.

i. Set B.O. CAP switch at 0 uf.

j. Connect a resistance decade box with sufficient resistance decades to measure the resistance with the desired accuracy, to the EXT binding posts.

k. Assign the input so Line 1 is connected to Trace 1.

l. Push the CONTINUOUS UPDATE button for Trace 1.

m. Set the RECEIVE dBm switch to between 0 and −30 dBm as required to see the pattern on the screen.

n. Vary the resistance of the decade box until the display in the region between 40 and 100 Hz reaches a maximum downward vertical deflection. This region of observation over the specified frequency range applies only to **loaded** cable. The value of resistance on the decade box represents to total resistance of the short circuited cable pair. Divide by 2 to get the resistance of the tip or ring wires. Then divide by the resistance per unit length of the cable to determine the length. Cable manufacturing tolerances and temperature effects will affect the accuracy of the measurement.

o. On **non-loaded** cable the observations of the effect of the decade resistance changes can be made over the frequency range up to 300 Hz.

5.8 Determining Distance to an Open Circuit Fault. (Tip and ring open)

a. Follow the procedure outlined in Section 5.7.02 for loaded and non-loaded cables.

b. The length measured in terms of cable capacitance represents the distance to the open cirucit. The capacitance of the load coils must be taken into account as described under NOTE in 5.7.02.

5.9 Determing Distance to a Short Circuit Fault

a. Follow the procedure outlined in Section 5.7.04 for loaded and non-loaded cables.

b. The length measured in terms of cable resistance represents the distance to the short circuit.

5.10 Level Measurements USING Internal Generator

5.10.01 The built-in signal generator may be used to supply a manually adjustable signal or a sweep signal to a circuit under test. The level of the signal and the frequency response may be measured on the graticule. The following procedure is used.

a. Connect the R and T binding posts under SEND to the input of the circuit under test.

b. Connect the Line 1 binding posts to the output of the circuit under test.

c. Push the appropriate SEND IMPEDANCE button.

d. Push the appropriate INPUT IMPEDANCE button.

e. Push either the BRDG or TERM button under SEND IMPEDANCE depending on whether the measurement is to be made on a bridging or terminated basis.

f. Push the appropirate FREQ RANGE button for the frequency range to be measured.

g. Set the SEND dBm switch to 0 dBm.

h. Push the LEVEL button under FUNCTION.

i. Assign Line 1 to Trace 1.

j. Push the CONTINUOUS UPDATE button for Trace 1.

k. Push the X10 button under VERTICAL SCALE MULTIPLIER.

l. Push the SW button under TUNING.

m. Adjust the RECEIVE dBm attenuator until the length of a selected reference frequency is at the 0 dB line on the graticule. The loss or gain of the device under test will be the reading on the attenuator for the 0 dB reference line on the graticule.

n. If better resolution of variations in the response characteristic is desired, push the desired VERTICAL SCALE MULTIPLIER button.

5.11 Level Measurements Using an External Signal Generator

5.11.01 Measurements may be made using an external sweep generator such as the Wilcom Model T205 Sweep Generator or a manually controlled variable frequency generator located at the far or remote end of a circuit.

a. Connect the Line 1 binding posts to the output of the circuit under test.

b. Connect the external generator to the far end of the circuit under test.

c. Set the output impedance of the far end generator to the desired impedance.

d. Set the output level of the far end generator to 0 dBm.

e. Push the appropriate INPUT IMPEDANCE button of the T195 to match the output impedance of the far end generator.

f. Push either the BRDG or TERM button under SEND IMPEDANCE depending on whether the measurement is to be made on a bridging or terminated basis.

g. Push the appropriate FREQ RANGE button for the frequency range to be measured.

h. Push the LEVEL button under FUNCTION.

i. Assign Line 1 to Trace 1.

j. Push the CONTINUOUS UPDATE button for Trace 1.

k. Push the X10 button under VERTICAL SCALE Multiplier.

l. Push the TRACK button under TUNING.

m. Sweep the frequency range of the far end generator automatically or manually. The pattern on the screen will follow this sweep, and the digital readout will show the frequency of the received signal. Best results will be obtained if the frequency is swept from low to high frequency.

n. Adjust the RECEIVE dBm attenuator until the level of a selected reference frequency is at the 0 dB line on the graticule. The loss or gain of the device under test will be the reading on the attenuator for the 0 dB reference line on the graticule.

o. If better resolution of variations in the response characteristic is desired, push the desired VERTICAL SCALE MULTIPLIER button.

p. When two channels are to be measured simultaneously using the dual output of the T205 Sweep Generator, it is necessary to first have the sweep on Trace 1 completed, and then push the SINGLE UPDATE button for Trace 1. The second trace will then be completed on Trace 2 if the CONTINUOUS UPDATE button is engaged.

5.12 Level Measurements Using External Fixed Frequency Generator

5.12.01 The level and frequency of a signal from a fixed frequency generator can be measured.

5.12.02 When the fixed signal source is at a remote location, such as a milliwatt generator test line, the procedure of 5.11 can be followed except the TUNING on the T195 should be set for SW. The level can then be measured on the graticule; it appears as a straight horizontal line on the screen.

5.12.03 After the level has been measured, push the TRACK button under tuning. The frequency of the received signal can now be read on the SEND FREQUENCY display.

5.13 Loop Around Level Measurements

5.13.01 Loop around measurements can be made in accordance with the procedures outlined in section 5.10 when the loop around connections are made manually at the far end.

5.13.02 When loop around measurements are made through a loop around test line the same procedure may be used after the test line has been called in accordance with the following procedure.

a. One line should be connected to SEND binding posts and the other to the Line 1 binding posts.

b. Connect a lineman's telephone set to the posts marked DIAL.

c. Push in the DIAL button under Line 1.

d. Call the number of the loop around test line associated with the milliwatt generator.

e. When the call has been completed push the HOLD button in under Line 1 and release the DIAL button to disconnect the telephone set from the circuit.

f. Note the level of the received signal on the graticule as set by the RECEIVE attenuator.

g. Push in the DIAL button under SEND.

h. Call the number of the loop around test line associated with the quiet termination. When the call is completed the loop around should be established.

i. Push in the HOLD button under SEND and release the DIAL button.

j. The signal from the sweep generator should now be sent through the loop around circuit. Adjust the RECEIVE dBm attenuator until the response curve of the looped circuit appears at the 0 dB line on the graticule. The attenuator will read the loop around loss.

5.14 Return Loss Measurements with Precision Networks

a. Terminate the far end of the line to be tested in a precision network required for that line, and an adjustable build-out capacitor. If the required build-out capacitance is known, use a fixed capacitor of that value. If unloaded cable is to be tested, use the appropriate network.

b. Connect the near end of the line to the Line 1 binding posts.

c. Push the RTN LOSS button under FUNCTION.

d. Connect a precision network required for the cable pair under test to the EXT NETWORK terminals.

e. Set the VERTICAL SCALE MULTIPLIER to X10.

f. Push the SW button under TUNING.

g. Push the 4 K button under FREQ RANGE.

h. Push the EXT button under RET LOSS NET.

i. Be sure both buttons under IMPEDANCE COMPENSATOR are released.

j. Assign Line 1 to Traces 1 and 2.

k. Push the CONTINUOUS UPDATE button for both traces.

l. Push the AVERAGE OVER BAND button for Trace 2.

m. Adjust the BAND LIMITS controls so the horizontal line representing the average return loss spans the frequency band over which the return loss is to be measured.

n. Set the B.O. CAP to 0 uf.

o. Set the SEND dBm switch to 0 dBm.

p. Set the RECEIVE dBm switch to 0 dBm.

q. Increase the value of the B.O. CAP and note the position of the horizontal line representing the averagae value of the return loss. As the B.O. CAP is increased this line should move downward in the vertical direction. When it approaches the bottom of the graticule change the RECEIVE dBm attenuator to −30 dBm. Keep changing the value of the B.O. CAP until the downward motion of the horizontal line stops and then starts up. The capacitance at which the motion of the line stops before going up, represents the build-out capacitance for the best return loss.

r. The average return loss is the reading on the vertical dB scale of the graticule X10 plus the reading on the RECEIVE dBm attenuator.

5.15 Return Loss Measurements With Compromise Network and Impedance Compensator.

a. Follow the procedure outlined for section 5.14 except as follows.

b. Do not connect a precision network to the EXTERNAL NETWORK terminals.

c. Push the 600 or 900 button for the COMPROMISE NET under RET LOSS NET.

d. Push either the D66 or H88 button under IMPEDANCE COMPENSATOR as required for the type of loading used. These are not used for non-loaded cable.

e. Follow the measurement procedure outlined in 5.14.

5.16 Comparing Against An Artificial Line

a. Set up the desired test procedures for checking a line as described in the previous sections.

b. Connect an artificial line to the LINE 2 or STD binding posts.

c. Push the appropriate button under COMPARE for comparing the lines connected to the set.

d. Assign LINE 1 to Trace 1, and LINE 2 or STD, whichever is used, to Trace 2.

e. Push the CONTINUOUS UPDATE buttons for both traces. The pattern for LINE 1 appears on Trace 1 and the pattern for the artificial line appears on Trace 2.

f. If it is desirable to separate the traces to simplify the examination of each pattern, place the V-POS-REF toggle switches for both traces in the upward or V-POS position. The V-POS controls next to the toggle switches may now be operated to position both traces as desired on the screen.

g. If no changes are to be made to the line under test on LINE 1, it is desirable to push the SINGLE UPDATE button for Trace 1. The only changes that occur will be on Trace 2 when the artificial line components are varied to match the pattern for LINE 1.

h. If a standard pattern such as obtained from an ideal line is to be retained on the screen, push the SINGLE UPDATE button for Trace 2 and leave the CONTINUOUS UPDATE button in on Trace 1. Now any changes that take place on the line under test can be compared to the standard. Successive lines can be connected to LINE 1 for comparing each line to the standard or artificial line.

5.17 Locating Bridged Taps

5.17.01 The procedure to be used for locating bridged taps is essentially the Capacitance Comparison Method used for determining the length of a cable as described in 5.7.02. The detailed procedure is described below. The procedure is effective on loaded cable, but on non-loaded cable it is only possible to determine that the cable has an excessive amount of capacitance.

a. Connect the cable pair to be tested to the LINE 1 binding posts.

b. Connect an artifical line with the **identical** makeup of the cable pair to be tested, to the LINE 2 binding posts.

c. Assign LINE 1 to Trace 1 and LINE 2 to Trace 2. Push the L1 - L2 button under COMPARE.

d. Set VERTICAL SCALE MULTIPLIER to X10.

e. Set SEND attenuator to 0 dBm.

f. Push FUNCTION - IMP button.

g. Push EXT button under RET LOSS NET.

h. Be sure the IMPEDANCE COMPENSATOR buttons are released.

i. Set TUNING at SW.

j. Set FREQ RANGE at 400 for loaded cable.

k. Connect the EXTERNAL NETWORK binding posts to the STD binding posts.

l. Push the CONTINUOUS UPDATE button for both traces. Once the patterns have been established it may be more convenient to push the SINGLE UPDATE button for Trace 1.

m. The pattern appearing on the screen represents the capacitance reactance curves of the line under test and the artificial line. If the two curves are coincident over the frequency range shown in the chart of section 5.7.02n, the line under test has the correct length. If the curve for LINE 1 is shifted to the left with respect to the curve for LINE 2, the line under test is longer than the artificial line and it may be assumed that a bridged tap exists on the line under test. The length of this tap can now be determined.

n. Push the L1 - STD button under COMPARE and assign L1 to Trace 1 and STD to Trace 2. The two curves which appear on the screen represent the capacitive reactance curves of the line under test and the B.O. CAP on the set.

o. Increase the B.O. CAP from 0 until the two curves are coincident as previously specified. The value of the B.O. CAP capacitance represents the capacitance of the pair under test. This number should be noted.

p. Push the L2 - STD button under COMPARE and assign L2 to Trace 1 and STD to Trace 2. The two curves which appear on the screen represent the capacitive reactance curves of the artificial cable and the B.O. CAP on the set.

q. Reduce the value of the B.O. CAP from that noted in o. above until the two curves coincide again. The difference between the value of the B.O. CAP in o. and the new value represents the length of the bridged tap in terms of its capacitance. The following tests should now be made.

r. Change the VERTICAL SCALE MULTIPLIER to X5 or whatever position will give the best size pattern in the following procedure.

s. Push the 4K button under FREQ RANGE.

t. Push the L1 - L2 button under COMPARE and assign L1 to Trace 1 and L2 to Trace 2. The patterns on the screen now represent the impedance characteristics of the line under test and the artificial line.

u. Sections of artificial line made up to represent the length of the bridged tap as determined in q. should now be added to various points along the artificial line until the impedance characteristic of the artificial line matches the impedance curve of the line under test. When the two curves match, the point at which the bridged tap has been added to the artificial line is the location of the tap on the line under test.

v. If it is suspected that the bridged tap is loaded, an appropriate loaded tap must be used. With experience, the effect of a loaded tap as compared to a non-loaded tap can be observed.

5.17.02 However, another test can be made to determine if a bridged tap is loaded. This requires a sweep generator, such as the WILCOM T205, to be connected to the far end of the cable pair under test and to make a level measurement which will display the frequency response of the pair under test. A loaded bridged tap will produce a dip or a series of dips in the frequency response. This characteristic can then be duplicated on the artificial line by sweeping it with the sweep generator in the T195, and connecting a loaded bridged tap at various points.

5.18 Comparing Tip and Ring Characteristics with Respect to Ground

a. Connect the tip wire of a cable pair and a cable or office ground to the Line 1 binding posts.

b. Connect the ring wire and the same ground to the Line 2 binding posts.

c. Push the L1 - L2 button under COMPARE and assign L1 to Trace 1 and L2 to Trace 2.

d. Set up the desired test using the procedures previously outlined.

e. If the two patterns are not identical, a fault exists on the tip or ring. Comparison with an artificial line can determine the nature of the trouble. A frequency response curve for both tip and ring with respect to ground can frequently determine the side which has the trouble. This test requires connection of a sweep generator such as the WILCOM T205 at the far end of the cable. Tip to ground and ring to ground connections must be made separately and displayed characteristics must be stored for comparison by pushing the SINGLE UPDATE button as required.

5.19 Checking for Split Pairs

5.19.01 This requires the use of an artificial cable kit that can be set up to introduce split pair configurations. The WILCOM T240 Artificial Cable Kit is designed to accomplish this.

5.19.02 The desired test, usually a comparison of the impedance characteristic of the line under test and artificial cable, should be set up in accordance with previous instructions. The split should be set up at various points on the artificial cable which represent the possible locations at which a split could be made. the characteristics of the cable and artificial cable are then compared.

5.20 Test for Bridged Ringers

5.20.01 The presence of bridged ringers on a line under test may be determined by the following procedure.

NOTE: It is possible that the presence of other devices having a resonant condition similar to a ringer may also show a characteristic similar to that produced by ringers.

a. Connect the cable pair to be tested to the LINE 1 binding posts.

b. Connect an artificial line with the same makeup as the cable pair to be tested to the LINE 2 binding posts. This is not essential but it will be useful in helping to analyze the effect of the presence of ringers on the line under test.

c. Push the L1-L2 button under COMPARE.

d. Assign LINE 1 to Trace 1 and LINE 2 to Trace 2.

e. Push CONTINUOUS UPDATE buttons for Traces 1 and 2.

f. Set VERTICAL SCALE MULTIPLIER at X10.

g. Set FREQ RANGE at 400.

h. Set SEND attenuator to 0 dBm.

i. Push FUNCTION - IMP button.

j. Push EXT button under RET LOSS NET.

k. Be sure the IMPEDANCE COMPENSATOR buttons are released.

l. Set TUNING at SW.

m. The patterns appearing on Traces 1 and 2 represent the capacitive reactance curves of the line under test. It is important that the curves have a peak close to the top of the graticule and that they are not flattened. If they should be flat, reduce the SEND level until a peak appears. If a very long cable is being checked, it may be necessary to adjust the SEND ATTENUATOR to a higher or + level to see a suitable peak.

n. If no ringers are bridged across the line or there are no grounded ringers, the two curves should be virtually coincident. If a ringer is bridged on the line under test, a dip will occur at approximately 30 Hz on the pattern on Trace 1. The depth of the dip is usually indicative of the number of ringers on the line. The number can be verified by adding ringers to the end of the artificial line until the same depth of dip is noted on Trace 2. Grounded

ringers usually distort the pattern between 20 and 70 Hz; tests for grounded ringers are described in 5.21.

5.21 Test for Grounded Ringers

a. Connect the tip lead of the pair under test and ground to the LINE 1 binding posts.

b. Connect the ring lead of the pair under test and ground to the LINE 2 binding posts.

c. Follow steps c through l of section 5.20.

d. Grounded ringers on the tip and ring will show up as a dip at approximately 30 Hz. An equal number of ringers on tip and ring will result in equal dips on both traces. If the dip on one pattern is deeper than the other, an unequal number of ringers is indicated. By placing the toggle switch for Trace 1 in the V-POS setting and varying the positioning control, it is possible to determine whether the tip or ring has the most ringers. The actual number of ringers on each side can be determined by substituting either the ring or tip leads with an artificial line that has a ground path, such as in the WILCOM T240 Artificial Cable Kit; and adding ringers to ground until the patterns on the line under test are matched.

5.22 Noise Measurements

5.22.01 Noise metallic measurements may be made with flat weighting or a low frequency reject weighting which give the results similar to C-message weighting for most noise conditions. An indication of the variation in the noise amplitude over a time period may be observed, and a rough idea of the range of dominant noise frequencies in the noise spectrum being measured can be noted. If the pair to be tested is not a working pair, an appropriate termination and ground return path must be connected to the far end of the pair. If a working pair is to be tested, the quiet termination in a C.O. should be called in accordance with the instructions in 4.3.

a. Connect the pair to be tested to the LINE 1 binding posts.

b. Push the L1-L2 button under COMPARE.

c. Assign LINE 1 to Trace 1.

d. Push CONTINUOUS UPDATE button on Trace 1 and the SINGLE UPDATE button for Trace 2.

e. Push the X10 MULTIPLIER button.

f. Push the FUNCTION - LEVEL button.

g. Push the 4K FREQ RANGE button.

h. Push the SW TUNING button.

i. Push the appropriate INPUT IMPEDANCE button.

j. Set the RECEIVE attenuator to −59 dBm.

k. When C-message weighting is to be approximated, push the LOW FREQ REJ button in. When flat weighting is wanted, release the LOW FREQ REJ button.

l. After the termination is connected to the far end as mentioned in the opening paragraph, the pattern on the cathode ray tube screen should indicate the variation of noise level over the time interval of the sweep. If the trace appears at the top of the graticule, change the setting of the RECEIVE attenuator until a conveniently located pattern is observed. The average value of the noise may be estimated or if Trace 2 is used as well as Trace 1 to observe the same pattern, push the AVERAGE OVER BAND button to adjust the BAND LIMITS controls to give a line between approximately 500 and 2500 Hz. The noise is measured in dBm. Thus, if the average noise level is −80 dBm, the noise in dBrn is 10 dBrn. If the LOW FREQ REJ is pushed in, the noise is in dBrnc.

m. It is possible to get a rough idea of the range of dominant frequencies in the noise spectrum being measured. This may be done by pushing the TUNING TRACK button and noting the range of frequencies the marker is jumping. The SEND FREQUENCY display will also jump from frequency to frequency but will be difficult to read unless only one or two frequencies constitute the noise being measured.

5.23 Recording Patterns by Camera or Tracings

a. The Tektronix C-5A camera may be used to record patterns displayed on the T195. Since the graticule is not coincident with the face of the CRT, there will be some shadows from the top graticule lines.

b. A polaroid camera with a close-up lens and mounted on a tripod or a solid stable surface may also be used. The camera should be placed so the lens is about 10" from the graticule and then focused. The brightness of the trace can be adjusted with the INTENSITY control. Incident light does not hurt the picture; however, bright sunlight should be avoided and a shade should be used.

c. Plastic overlays with the graticule pattern are available. They snap on to two posts which are on the graticule. A grease pencil can be used to trace the pattern.

d. Tracing paper will also be available.

5.24 Recording With an X-Y Plotter

5.24.01 X, Y, and GND binding posts are available on the front panel for connecting an X-Y plotter. The speed of the sweep is approximately 5 seconds, so a plotter capable of handling this speed to trace the pattern should be used. The voltages or current available for the plotter are shown in the specifications for the T195.